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of

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for

**APPARATUS AND METHOD FOR DYNAMICALLY
ALLOCATING COMPUTER RESOURCES
BASED ON SERVICE CONTRACT WITH USER**

APPARATUS AND METHOD FOR DYNAMICALLY ALLOCATING

COMPUTER RESOURCES BASED ON SERVICE CONTRACT WITH USER

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus and method for allocating resources of a computer system to users. More particularly, the invention relates to an apparatus and method for allocating computer resources of a system constituted of a plurality of computers interconnected by a network, the apparatus and method being capable of allocating computer resources in real time, the computer resources being necessary for maintaining a service level contracted beforehand with each user while a plurality of user's requests are processed, and capable of guaranteeing securities between users.

Business types are increasing which outsource intra-company information system running and company home page management to an ASP (application service provider) in order to reduce the cost of an information department. Many ASP's outsource supply, running and management of computer resources to a data center.

The data center prepares a plurality of computer resources and allocates them to a plurality of user companies in order to reduce the running cost of the data center itself and supply low price services to the user companies. In order to guarantee securities between user companies, generally the data center often

allocates different computer resources and storage resources to each user company.

A user company load fluctuates between time zones, seasons and the like. From this reason, the data center often contracts with a user company so as to increase or decrease allocated resources in accordance with the user company load. The company load, particularly the load of the company whose home page management is outsourced, is difficult to predict because many and unidentified consumers access the home page via the Internet. In order to deal with this, a user company contracts with a data center under the contract term that a predetermined number of computer resources are increased during a predetermined period by predicting on the user company side an increase in the load to be caused by a new product announcement. The data center allocates the increased computer resources to other user companies during the other period to efficiently utilize the resources. In order to facilitate such a configuration change, the data center is configured in such a manner that a load allocating apparatus is installed at the front stage of a plurality of computer resources to allocate the computer resources to a user company A during some period and some computer resources to a user company B during the other period. An example of the load allocating apparatus is an ACE director of Alteon Websystems. A load allocating apparatus is disclosed,

for example, in Nikkei Open Systems, 1999, 12, No. 81, pp. 128 - 131. Settings of a load allocating apparatus, for example, the number of allocated servers, is manually made by the data center in

5   accordance with a contract with a user company, such as the contract described above. If it is necessary to increase storage resources, it is necessary to perform mirroring of the contents of storages.

        Since a data center provides different

10 computer resources to each of a number of user companies, the management cost for the number of computer resources increases. In order to avoid this, it is conceivable that a small number of computer resources each having a high performance, e.g., highly

15 multiplexed computers SMP, are introduced and a plurality of user companies share them. In order to guarantee securities between user companies, a virtual computer function is utilized. An example of the virtual computer is a Processor Resource Management

20 Feature PRMF of Hitach Ltd. PRMF is disclosed, for example, in the HITAC manual 8080-2-148-60. According to PRMF, a plurality of operating systems (OSes) run on one computer, and independent resources such as main storages and network adapters are allocated to each OS.

25 Since resources are not shared among OSes, securities are guaranteed between programs of different user companies executed on different OSes. Although PRMF is configured so that ratios of CPU resources allocated to

OSes can be controlled, a ratio change is limited only
to those ratios planned beforehand.

It is becoming usual to make a service level
contract between and ASP's and ISP's (Internet service
5   provider) and user companies. A user makes a contract
with ASP to guarantee a service level such as
connectivity, availability and latency performance. In
addition to this contract, a compensation contract for
the case that the guarantee level is not realized is
10 often made.

U.S. Patent No. 5,774,668 discloses that a
data center having a plurality of application servers
monitors the load of each service application and
increases or decreases the number of application
15 servers in accordance with a change in the load.
However, in U.S. Patent No. 5,774,668, a process load
of each user (client) is not monitored. Further, U.S.
Patent No. 5,774,668 does not teach that the data
center increases or decreases the number of application
20 servers in order to maintain the service level
contracted with each user (client).

With the manual setting of a load allocating
apparatus by a data center based on the contract with a
user company, it is difficult to deal with in real time
25 an abrupt load change not predicted by the user
company. This is also applied to the case that
different computers are allocated to each user company
or that a virtual computer is used. It is difficult to

increase storage resources rapidly because of an overhead of data copy for mirroring. In the case of a data center, the latency performance and the like are difficult to be defined and measured if the process

5 contents are not stereotyped, e.g., if a process request from one user company is processed by a plurality of computers.

SUMMARY OF THE INVENTION

In order to solve the above-described

10 problems, an object of the invention is to provide a resource allocating apparatus and method for allocating, dynamically or in real time, computer resources and storage resources of a data center to each user company in response to a load change of each

15 user company.

To this end, according to the invention, a user identification table is prepared for each service level contract made between each user company and the data center, this table storing information on a

20 correspondence between a unique user ID and a user company. A related user company is identified from a user request packet sent to the data center. The packet is added with the user ID corresponding to the service level contracted with the user company. A

25 management server forms a definition table for defining a group of computers which processes the user request belonging to each user ID, and dynamically sets the

definition table to the load allocating apparatus. The
load allocating apparatus selects a computer group from
groups set to the definition table to make it execute
the user request. If there is a plurality of load
5 allocating apparatus, the management server controls to
maintain integrity of the definition table between load
allocating apparatus.

Furthermore, the management server monitors
the operation state of each computer to check whether
10 the service level contract with each user company is
satisfied or not, and if necessary increases or
decreases computer resources. Specifically, the
management server changes a computer group in the
definition table and sets it again to the load
15 allocating apparatus.

Still further, the management server forms a
history of information on whether the computer resource
amount and service level contract corresponding to each
user ID are satisfied, to thereafter form charge
20 information. In order to measure the process
throughput of the whole data center, the number of user
requests and responses transmitted to and from the data
center may be measured for each user ID.

According to another embodiment of the
25 invention, the data center is structured by using
computers having a virtual computer mechanism. Each
user company is provided with a virtual computer
mechanism under the control of one OS, and the

management server dynamically sets a use allocation rate of CPU of each computer mechanism, to each computer. The management service monitors the operation state of each computer to check whether the
5 service level contract is satisfied, and if necessary increases or decreases the use allocation rate of CPU.

According to the invention, each user company is provided with a user ID for identifying the contracted service level, and in accordance with the
10 user ID, computer resources are supplied. In accordance with the monitoring result of the operation state of each computer, the computer resource amount can be automatically increased or decreased through comparison between the monitoring result and the
15 service level contract corresponding to each user ID. In this manner, a computer resource allocation can be changed in real time even for a rapid load change not predicted on the user company side.

In the embodiments of the invention, although
20 a juridical corporation is used by way of example as a user making a service level contract with the data center, the invention is also applicable to a private user depending upon conditions. Therefore, in the specification, a user company is often described simply
25 as a user.

Even if a computer resource allocation is changed, storage resources are shared by all computers and the storage side checks an access privilege from

the user ID. Therefore, securities between users can be guaranteed without an overhead of mirroring.

Further, the numbers of requests and responses per unit time passing through the data center are measured and collected for each user ID. It is therefore easy to measure the performance of the data center as viewed from users.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing an example of the structure of a system constituted of a data center and users interconnected by the Internet.

Fig. 2 is a diagram showing an example of the structure of a data center.

Fig. 3 is a diagram showing the structure of a gateway shown in Fig. 2.

Fig. 4 a diagram showing the structure of a management server shown in Fig. 2.

Figs. 5(A) to 5(C) are diagrams showing examples of tables possessed by a load allocating apparatus shown in Fig. 2.

Fig. 6 is a diagram showing an example of a table possessed by a storage shown in Fig. 2.

Figs. 7(A) to 7(O) are diagrams showing the structures of packets passing through signal lines shown in Fig. 2.

Fig. 8 is a flow chart illustrating an example of an ordinary operation of a control program

shown in Fig. 4.

Figs. 9(A) and 9(B) are block diagrams showing another example of an ordinary operation flow of the control program shown in Fig. 4.

Fig. 10 is a diagram showing another example of the structure of the data center.

Fig. 11 is a diagram showing data stored in LPAR control registers shown in Fig. 10.

Figs. 12(A) to 12(O) are diagrams showing the structures of packets passing through signal lines shown in Fig. 10.

Fig. 13 is a diagram showing the structure of a management server shown in Fig. 10.

Fig. 14 is a flow chart illustrating an example of the ordinary operation of a control program shown in Fig. 13.

Fig. 15 is a diagram showing another example of the structure of the data center.

Figs. 16(A), 16(C), 16(D), 16(M) and 16(O) are diagrams showing the structures of packets passing through signal lines shown in Fig. 15.

Fig. 17 is a diagram showing the structure of a gateway shown in Fig. 15.

Fig. 18 is a diagram showing the structure of a management server shown in Fig. 15.

Fig. 19 is a flow chart illustrating an example of the operation of a control program shown in Fig. 18.

Fig. 20 is a flow chart illustrating an example of an initial operation of the control program shown in Fig. 4.

Fig. 21 is a flow chart illustrating an example of an initial operation of a control program shown in Fig. 13.

Fig. 22 is a diagram showing a condition input dialog for a user using the data center shown in Fig. 2.

Fig. 23 is a diagram showing a service level condition input dialog for a user using the data center shown in Fig. 2.

Fig. 24 is a diagram showing a service level condition input dialog for a user using the data center shown in Fig. 9.

Fig. 25 is a diagram showing a condition input dialog for a user using the data center shown in Fig. 15.

DESCRIPTION OF THE EMBODIMENTS

Embodiments of the invention will be described with reference to the accompanying drawings.

A first embodiment is shown in Fig. 1. In the example shown in Fig. 1, a data center as the main subject of this invention is connected via the Internet II0 to a user company A (AA0), a user company B (BB0) and consumers c0 and c1 accessing the home pages of the A and B companies. Clients a0, a1 and a2 have private

network addresses (PNA) of an A company system and
access a gateway D0 in the data center via gateways A0
and A1 and a virtual private network (VPN). Requests
from the clients c0 and c1 will be later described in a

5 third embodiment.

Fig. 2 shows the structure of a data center
DD0. In this example, the data center has a three-
layer structure including a Web server group, an AP
server group and a DB server group. The Web server

10 provides a Web browser interface in response to a user
request. The AP server runs an application program
which is generated from a Web server. The DB server
deals with a database access request issued from an
application program.

15 Fig. 22 shows an example of an input dialog
to be used when the user company A makes a use
condition contract with the data center. In this
example, the contents of this contract are as follows.
A0 or A1 is used as the access request source IP

20 address of a request packet in order to identify that
an access request input to the gateway D0 is an access
request from a user belonging to the user company A.
In addition, the user company A can use all of the Web
server group, AP server group and DB server group of

25 the data center, and a program set up in response to a
user request of the user company A uses a100 as the IP
address of a Web server, a200 as the IP address of an
AP server and a300 as the IP address of a DB server.

Fig. 23 shows an example of an input dialog to be used when the user company A makes a service level contract with the data center. In this example, at least two Web servers, two AP servers and two DB servers are allocated to the user company A, and all the servers are made to run at a CPU operation rate smaller than 50 %. If the operation rate becomes 50% or higher, eight servers at a maximum are allocated, i.e., eight Web servers, eight AP servers and eight DB servers. In this example, although check symbols are not entered in the input dialog, an output transaction throughput, for example, at an output of the data center, a throughput ratio of an output transaction to an input transaction, and a transaction process latency may be entered in the service level contract.

It is assumed that in accordance with the contract made by the input dialog, Web servers a10 and a11, AP servers a20 and a21 and DB servers a30 and a31 are allocated to the A company, and Web servers b10 and b11, AP servers b20 and b21 and DB servers b30 and b31 are allocated to the B company, respectively as initial values. A storage S0 is allocated to the A and B companies in the unit of a volume. A volume V0 is allocated to the A company and a volume V1 is allocated to the B company. Storages S1 and S2 are allocated in the similar manner, although this allocation is not shown in Fig. 2. Servers y10 to y31 are reserved servers which are allocated when the loads of the A and

B companies become large.

It is assumed that the IP addresses used by the A company are a100 for the Web servers, a200 for the AP servers, and a300 for the DB servers.

5 Similarly, it is assumed that by using the input dialog, the IP addresses used by the B company are set to b100 for the Web servers, b200 for the AP servers, and b300 for the DB servers.

With reference to the relevant drawings, the description is given as to how the gateways A0 and D0, management server C0 and load allocating apparatus d100, d200 and d300 deal with a request from the user A by using the servers a10 to a31.

The structure of a request packet which the client a0 sends to the gateway A0 shown in Fig. 1 is shown in Fig. 7(A) at 1200. A start field (a100) of the packet corresponds to the address of a destination server, and the next field (a0) corresponds to the address of a source client. When the packet 1200 is sent to the Internet II0, the gateway A0 capsulizes the packet for a virtual private network (VPN) to form a packet 1201 shown in Fig. 7(A). The gateway D0 uncapsulizes this packet to obtain the packet 1200. Since this technology is well known, the detailed description thereof is omitted.

Fig. 3 is a diagram showing the structure of the gateway D0 at the input of the data center DD0. The gateway D0 uncapsulizes the packet shown in Fig.

7(B) input from a signal line I0, obtains a user ID #0
by referring to a user ID table T10, and adds #0 to the
packet to generate a packet 1202 shown in Fig. 7(C) and
send it to a signal line L10. The user ID table T10 is

5   formed by the management server C0 in accordance with
the user condition input dialog shown in Fig. 22 and
set beforehand to the gateway D0 via a signal line L0.
Namely, the request which accessed the data center DD0
by using the source address A0 or A1 is regarded as the

10   request from the user having the user ID #0, i.e., the
request from the A user.

At the same time when the packet 1202 is
generated, a counter circuit 1003 of the gateway D0
counts a pass of the input request having the user ID

15   #0 and a count result is set to an input/output result
storage table T11.

The load allocating apparatus d100 which
received the packet 1202 via the signal line L10 has a
server address correspondence table T30 shown in Fig.

20   5(A). This table T30 stores, for each user ID,
information on to which real server a request to
servers, which was input in the dialog shown in Fig. 22
as a user application, is sent. Since the packet 1202
has the user ID #0 and the destination address a100,

25   the load allocating apparatus d100 changes the
destination server address a100 to either a10 or a11 by
referring to the table T30, and generates a packet 1203
shown in Fig. 7(D). This technology of selecting and

changing the destination address is well known, and so the detailed description thereof is omitted.

The Web server a10 receives the packet 1203, and if a process at an AP server is necessary,

5   generates a packet 1204 (Fig. 7(E)) for requesting an access to a200. This packet 1204 is sent via a bus L110 to a load allocating apparatus d200. The load allocating apparatus d200 has a server address correspondence table T31 shown in Fig. 5(B). By

10 referring to this table, the load allocating apparatus d200 changes the destination server address a200, for example, to a20 to generate a packet 1205 (Fig. 7(F)).

Similarly, the AP server a20 generates, if necessary, a packet 1206 (Fig. 7(G)), and a load

15 allocating apparatus d300 having a server address correspondence table T32 (Fig. 5(C)) changes the packet 1206 to a packet 1207 (Fig. 7(H)) to make the DB server a30 process this packet.

A response from the DB server a30 to the AP

20 server a20, Web server a10, and to client a0 is returned in a manner similar to that described above. In this case, packets 1208 (Fig. 7(I)) to 1214 (Fig. 7(O)) are sequentially generated. When the gateway D0 sends the response packet 1213 (Fig. 7(N)) to the

25 gateway A0, the counter circuit 1003 of the gateway D0 counts a pass of the output request having the user ID #0 and a count result is set to the input/output result storage table T11.

Although not described above, when a request is issued from the user company B, the gateway D0 adds a user ID #1 to the packet in the similar manner to that described above, and the packet is sequentially processed by the servers b10 to b31 in the similar manner to that described above.

With the above operations, the servers for executing the processes of the users A and B are divided into or allocated as the servers a10 to a31 and the servers b10 to b31.

Access to the storage will be described by taking as an example the storage S0 shown in Fig. 2. The storage S0 is shared by all Web servers by a signal line L120. When each server accesses the storage, the user ID is added to the access request. The storage S0 has a volume access privilege table T33 shown in Fig. 6. This table T33 stores, for each user ID, information on which volume is permitted to access. If the access request of the user ID #1 is an access to the volume V0, the storage S0 refers to this table T33 and rejects this access. Therefore, even if storage S1 is shared by all Web servers, securities between the users A and B can be guaranteed.

Referring to Fig. 2, the management server C0 monitors the operation states of the servers and load allocating apparatus via signal lines L100, L200 and L300. The monitoring contents are determined from the contents of the service level contract with each user

and the function of a monitoring program. For example,
the monitoring contents include a CPU operation rate, a
load allocating destination history and the like. The
monitoring program may run on the management server C0,
5 each server or each load allocating apparatus. The
management server C0 acquires the contents of the
input/output result table T11 of each user from the
gateway D0 via the signal line L0.

Fig. 4 is a diagram showing the structure of
10 the management server C0. T19 represents a user ID
table which is set by a control program P20 by using
the user condition input dialog shown in Fig. 22. T20
represents a service level contract content table for
each user, which table is set by the control program
15 P20 by using the service level condition input dialog
shown in Fig. 23. In this contract, the user having
the user ID #0 is allocated with at least two Web
servers, two AP servers and two DB servers, all these
servers run a program at a CPU operation rate smaller
20 than 50 %, and if the CPU operation rate exceeds this
level, the number of servers is increased to eight
servers at each server group at the maximum. In the
contract with the user having the user ID #1, the user
is allocated with at least two Web servers, two AP
25 servers and two DB servers, the access response
throughput of the data center is maintained 30
responses per second, and if the throughput lowers this
level, the number of servers is increased to six

servers at each server group at the maximum.

      With reference to the monitoring results and
the service level contract content table T20, the
control program P20 checks whether the current resource
5 allocation satisfies the service level contract, and
stores the check results in a service history storage
table T21. For example, CPU operation rate history of
all servers allocated to the user ID #0 is recorded in
the service history storage table T21. If the
10 monitoring result does not satisfy the service
contract, the control program P20 increases the number
of servers to be allocated. To this end, the
management server is provided with a server allocation
management table T22 and a server address
15 correspondence table T23. The server management table
T22 stores information on which server is allocated to
which user. The server address correspondence table
T23 is a correspondence table storing information on a
correspondence between the server name recognized by a
20 user application and an allocated real server. This
table T23 is a master table of server address
correspondence tables T30 to T32 possessed by the load
allocating apparatus d100 to d300. The server history
storage table also stores charge information. Although
25 not shown, if the contract with the user states that
the charge is increased in accordance with the number
of allocated servers, the charge calculation equation
changes so that the changed equation is reflected. If

the contract with the user states that the charge is
changed in accordance with the degree of not
maintaining the contracted service level, then this
change is reflected.

5   The procedure of the control program P20 of
the management server C0 to initially allocate
resources in order to execute the above-described
control will be described with reference to Fig. 20.

        The management server C0 which executes the
10 control program P20 first acquires the information
entered in the user condition input dialog shown in
Fig. 22 to generate the user ID table T19 (Step 1901).
Next, this information is set to the gateway D0 via the
signal line L0 (Step 1902).

15   The management server C0 acquires the
information entered in the service level condition
input dialog shown in Fig. 23 to generate the service
level contract content table T20 and the virtual
address field in the service address correspondence
20 table T23 (Step 1903). Next, servers are allocated
from each of the Web server, AP server and DB server
groups. Specifically, after confirming that each user
is allocated with at least two servers of each group,
by referring to the service level contract content
25 table T20, the management server C0 generates the
server allocation management table T22 and the real
address field of the server address correspondence
table T23 (Step 1904). Next, a necessary portion of

the generated server address correspondence table T23
is copied to the load allocation apparatus d100, d200
and d300 via the signal lines L100, L200 and L300 (Step
1905).

5   With reference to the service level contract
content table T23, the service history storage table
T21 is generated (Step 1906). Specifically, a field
for recording the CPU operation rate history is
generated for the user ID #0 and a field for recording

10   a transaction output throughput history (not shown) is
generated for the user ID #1.

       With the above operations, information
necessary for the resource allocation control is
prepared and set to the gateway D0 and the load

15   allocating apparatus d100, d200 and d300, so that the
system can start its operation under the conditions of
proper resource allocation.

       Next, the procedure of the control program
P20 to change a resource allocation when the load

20   increases will be described with reference to Fig. 8.

       As described earlier, the operation
information of the system is monitored via the signal
lines L100, L200, L300 and L0 (Step 1301). The
operation information of each user ID is collected and

25   stored in the service history storage table T21 (Step
1302). After the service history storage table T21 is
compared with the service level contract content table
T20 (Step 1303), it is checked whether the number of

servers can be reduced from the viewpoint of the
service level contract (Step 1304). As a method of
judging whether the number of servers can be reduced, a
proportional calculation between products of CPU
5 operation rates and the numbers of servers may be used.
For example, although the service level condition of
the user #0 has a CPU operation rate smaller than 50 %,
if four Web servers are currently allocated and the CPU
operation rate is all smaller than 25 %, then it can be
10 judged from a simple proportional calculation that the
number of Web servers can be reduced to two Web
servers. In practice, the number of servers is
multiplied by various safety coefficients given from
experiences. If the number of servers can be reduced,
15 a process termination instruction is notified to the
server to be removed, via a corresponding one of the
signal lines L100, L200 and L300. The notified server
terminates the program process and releases the
resource having been used. Namely, the contents of a
20 memory address translation table and a cache are
invalidated. After completion of the release, the
server notifies the release completion to the
management server. In response to this, the management
server instructs the load allocating apparatus d100 to
25 d300 to change the server address correspondence tables
T30 to T32. Next, it is checked whether the contents
of all the load allocating apparatus are coincident.
The charge calculation equation is changed. In this

example, the number of allocated servers and the
history of the allocated times are stored. For the
charge calculation, a unit charge of one server per
unit time is predetermined to calculate a charge.
5   Namely, the total number of servers, the history of
allocated times and the unit charge are multiplied
together to calculate the charge (Step 1305).

In this example, since the allocation history
is recorded distinguishably between the Web server
10 group, AP server group and DB server group, the unit
charge may be changed for each group to calculate the
charge from a product of the number of allocated
servers for each group, the history of the allocated
times and each unit charge. In this example, although
15 not shown, if the effective performance is different
among servers, it is apparent to calculate the charge
from a product of the number of servers, the effective
performance, the history of the allocated times, and
the unit charge. Also, in this example, the number of
20 request packets passing through the gateway D0 and the
number of response packets are recorded. If the
gateway passing throughput of request packets is
relatively stable, the gateway passing throughput of
response packets may be used as a criterion for
25 estimating the data center process performance. In
this case, the gateway passing throughput of response
packets may be received from the gateway via the signal
line L0 to calculate the charge through comparison with

a predetermined contracted standard throughput. For
example, the time during which the standard throughput
is satisfied may be charged by a specified charge
calculation, whereas for the time not satisfied the
5   standard throughput, a penalty may be subtracted from
the charge. By setting a unit charge for the standard
throughput, the charge may be calculated from (measured
throughput/standard throughput x unit charge). If the
input throughput of request packets fluctuates greatly,
10   the charge may be calculated from (response packet
throughput/request packet throughput).

        Returning back to Fig. 8, it is checked
whether it is necessary to increase the number of
servers (Step 1306). Checking how many servers are
15   increased may be performed, for example, by a
proportional calculation similar to reducing the number
of servers. If it is necessary to increase the number
of servers, by referring to the server allocation
management table T22 12 for each of the Web server, AP
20   server and DB server groups, it is checked whether
there is an idle server (Step 1307). If there is no
idle server, this effect is notified to the system
administrator (Step 1308). If there is an idle server,
a server to be allocated is selected (Step 1309) and
25   the load allocating apparatus d100 to d300 are
instructed to change the contents of the server address
correspondence tables T30 to T32. After it is
confirmed that the contents of all the load allocating

apparatus are changed and are coincident, the charge
calculation equation is changed (step 1310).

An example of the procedure by the control
program P20 of the management server C0 has been
5   described above. It is apparent that the whole of the
procedure is not necessarily required to be executed by
the control program P20. For example, monitoring and
collecting the operation information may not be
performed by the control program P20 but the operation
10   information may be received from another program. The
contents of the processes at Step 1305 and Step 1310
which the control program P20 executes essentially may
be replaced by Step 1405A(B) and Step 1410A(B) shown in
Figs. 9(A) and 9(B) in order not to change the charge
15   information. Further, if each server has a function of
not receiving a new user request after the process stop
instruction, as shown in Fig. 9(A) Step 1305 and Step
1310 may be replaced by Step 1405A and Step 1410A in
order to instruct to change the server address
20   correspondence tables T30 to T32 without waiting for
completion of the process stop.

In the above description, the volume access
privilege table T33 of the storage resources is not
changed. Even if the server allocation is changed, it
25   is possible to prevent the volume without an access
privilege from being accessed, because each program
accesses the storage by adding the user ID.

Next, a second embodiment of the invention

will be described in which the data center is configured by using highly multiplexed SMP servers with a virtual computer function PRMF.

The connection diagram for the data center and users is the same as that shown in Fig. 1.

The data center shown in Fig. 10 has one Web server, one AP server and one DB server each having a virtual computer function PRMF. The internal structures of the AP server 1501 and DB server 1502 are the same as that of the Web server 1500, and so the description thereof is omitted.

The user condition input dialog of the second embodiment is the same as that shown in Fig. 22. Namely, in this contract, only a user request packet having the source IP address of A0 or A1 is considered as the packet of the user company A. The IP addresses used by the user company A is a100 for the Web server, a200 for the AP server, and a300 for the DB server.

Fig. 24 is an example of a service level contract condition input dialog. In this example, the contract with the A company indicates that the CPU allocation rate by the PRMF function of each of the Web server, AP server and DB server is controlled to be 50 % or higher.

Reverting to Fig 10, the Web server 1500 is constituted of a control unit 1503, an LPAR control register group 1504, CPU's 1505 and 1506, a memory 1507 and network adapters a100, b100 and y100. LPAR is the

abbreviation of Logical PARtition (logical resource partition). The LPAR control register group 1504 stores information on a method of allocating resources to each OS.

5   Fig. 11 shows an example of information stored in the LPAR control register group 1504. A conventional technology PRMF has information other than the user identifier UID field. LPAR# is an identifier uniquely assigned to each resource to be allocated to

10 each OS. The network adapter is provided for each LPAR. A network adapter address is set to be identical to the IP address assigned to each user contracted by using the user condition input dialog. Therefore, a user request packet entering a network adapter is

15 passed to a program running on OS of the corresponding LPAR. A memory allocation field stores information on which area of the memory 1507 is used by each LPAR. A CPU allocation % field stores information on at what ratio an OS belonging to each LPAR and a program on OS

20 are operated on CPU's. The control unit 1503 refers to this information to control the operation ratio of LPAR's.

In this embodiment, the user identifier UID field is added which is made in one-to-one

25 correspondence with LPAR. Under the PRMF control, different LPAR's cannot share resources so that securities between users can be guaranteed.

Similar to the first embodiment, consider now

that a user request is passed from the client a0, to
the Web server a100, AP server a200, DB server a300, AP
server a200, Web server a100, and back to client a0.
The client a0 generates a packet 1200 shown in Fig.
5 12(A). The gateway A0 generates a packet 1201 (Fig.
12(B)), and the gateway D0 generates a packet 1202
(Fig. 12(C)), similar to the first embodiment.

        The packet 1202 is passed via the signal line
L0 to the network adapter a100 having the address a100
10 and to the application program on LPAR#0, i.e., an
application program of the user A. This program
generates a packet 1204 (Fig. 12(E)) having a
destination address a200. Thereafter, in a similar
manner, the packet is passed to an application program
15 of the A company on the AP server 1501 and to the
application program of the A company on the DB server
1502. (Although not shown, the AP server 1501 has
network adapters a200, b200 and y 200 corresponding to
LPAR#0, #1 and #2. The LPAR#0 and #1 correspond to the
20 user identifiers #0 and #1. This is also applied to
the DB server 1502.) Similarly, the response from the
DB server 1502 to the AP server 1501, Web server 1500
and to client a0 is performed by application programs
on LPAR's assigned to the A company. Although the
25 detailed description is not given, the above operations
sequentially generate packets 1206 (Fig. 12(G)) to 1214
(Fig. 12(O)).

        Fig. 13 is a diagram showing the structure of

the management server C0. T40 represents a LPAR
allocation management table, and T19 represents a user
ID table. T50 represents a service level contract
content table for each user. In this contract, a CPU
5 allocation rate of 50 % or higher is assigned to each
LPAR of all of the Web server, AP server and DB server
of the user having the user identifier #0. A CPU
allocation rate of 20 % at a minimum is assigned for
the user having the user identifier #1, an access
10 response throughput from the data center is maintained
30 transactions per second, and if there is a
possibility that this throughput is not satisfied, the
CPU allocation rate is increased. The control program
P20 refers to the monitoring results and service level
15 contract content table T50 acquired from the signal
lines L100, L200, L300 and L0 to check whether the
current resource allocation satisfies the service level
contract, and stores the check results in the service
history storage table T51. For example, the actual CPU
20 use rate history of LPAR of the user identifier #0 is
recorded. If the access response throughput of the
user identifier #1 is lower than 30 transactions per
second, the set CPU allocation rate is increased. To
this end, the management server C0 stores a CPU
25 allocation management table T52 which stores
information on what CPU allocation rate is set to which
user. This table 52 stores the same contents as those
in the CPU allocation rate field of the LPAR control

register group of each of the Web server, AP server and
DB server. The management of the charge information
field of the service history storage table T51 is
performed in the manner similar to the first
5 embodiment.

The procedure of the control program P20 to
initially allocate resources in order to execute the
above-described control will be described with
reference to Fig. 21.

10 The management server C0 first acquires the
information entered in the user condition input dialog
shown in Fig. 22 to generate the user ID table T19
(Step 2001). Next, this information is set to the
gateway D0 via the signal line L0 (Step 2002).

15 The management server C0 acquires the
information entered in the service level condition
input dialog shown in Fig. 24 to generate the service
level contract content table T50 and the network
adapter field in the LPAR allocation management table
20 T40 (Step 2003).

Next, the service level contract content
table T50 is referred to to confirm that a CPU
allocation rate of 50 % at a minimum is assigned to
the user identifier #0 and that a CPU allocation rate
25 of 20 % is assigned to the user identifier #1.
Thereafter, the CPU allocation fields of the CPU
allocation management table T52 and LPAR allocation
management table T40 are generated (Step 2004). The

contents of the LPAR allocation management table T4 are
set to the LPAR control register group of the servers
1500, 1501 and 1502 via the signal lines L100, L200 and
L300 (Step 2005). The service history storage table
5   T21 is then generated in accordance with the service
level contract content table T23 (Step 2006).

With the above operations, the management
server C0 prepares information necessary for the
resource allocation control and sets the information to
10   the gateway D0 and the servers 1500, 1501 and 1502, so
that the system can start its operation under the
conditions of proper resource allocation.

Next, the procedure of the control program
P20 to change a resource allocation when the load
15   increases will be described with reference to Fig. 14.

Operation information monitoring (Step 1601),
operation information collection (Step 1602) and
comparison with a service level contract (Step 1603)
are similar to respective Steps 1301, 1302 and 1303 of
20   the first embodiment shown in Fig. 8. It is thereafter
checked whether the CPU allocation rate can be reduced
(Step 1604). If possible, the management server
instructs to change the contents of the LPAR control
resister group of the corresponding server. A method
25   of checking whether the CPU allocation rate can be
reduced is similar to the first embodiment. After the
contents are changed, a charge calculation equation is
changed (Step 1605). In this example, histories of the

CPU use rate and allocated time are recorded. A unit charge per unit time is predetermined for each of the Web server, AP server and DB server to charge a total of unit charges multiplied by CPU use rates.

5   Obviously, the unit charge may be set differently to each of the Web server, AP server and DB server, or the unit charge may be set based upon an effective performance of each server.

     Next, it is checked whether it is necessary 10   to increase the CPU allocation rate (Step 1606). If it is necessary, it is checked whether the total of the CPU allocation rates set to the corresponding serve exceeds 100 % (Step 1607). If exceeds, this effect is notified to the system administrator (Step 1608). If 15   not exceed, the management server instructs to change the contents of the LPAR control register group of the corresponding server, and after this change, the charge information is changed (Step 1609).

     Lastly, a third embodiment will be described 20   in which many and unidentified general consumers access home pages provided by A and B companies.

     A connection diagram between a data center and users is the same as that shown in Fig. 1. General users are clients c0 and c1.

25   Fig. 15 shows the structure of a data center. Similar to the first embodiment, a load allocating apparatus d100 can distribute loads to a plurality of servers. For the purposes of description simplicity,

only Web servers are used. All the Web servers share a storage S4 via a signal line L120. The storage S4 stores files F0 and F1, the file F0 storing information including home page information of the A company and

5 the file F1 storing information including home page information of the B company. The home page information has a tree structure so that each information can be sequentially accessed from a root page. It is assumed that the address for accessing the

10 home page of the A company is a100 and that for the B company is b100.

Fig. 25 shows an example of an input dialog to be used for a contract between the A company and the data center to determine the condition of general users

15 accessing the home page. In this example, the contents of this contract are as follows. As the access destination IP address of an access request packet input to the gateway D0, a100 is used in order to identify that the access to the home page of the A

20 company is an access request from a user group belonging to the A company. In addition, the A company uses a100 as the IP address for creating a home page.

The client c0 generates a packet 1700 shown in Fig. 16(A) in order to access the home page of the A

25 company. The gateway 1700 has a user ID table T60 shown in Fig. 17. Since the destination address of the packet 1700 is a100, the gateway can know that the packet is to be accessed to the home page of the user

identifier #0, and generates a packet 1702 shown in
Fig. 16(C). Thereafter, the load allocating apparatus
d100 sends this access request to either a Web server
a10 or a11. In this example, the server a10 is
5 selected. A packet 1703 is therefore generated (Fig.
16(D). Similarly, the load allocating apparatus d100
changes the packet to a packet 1712 (Fig. 16(M)) as a
response packet which is changed to a packet 1714 (Fig.
16(O)) by the gateway D0 and returned to the client c0.

10   The internal structure of the management
server C0 is shown in Fig. 18. The structure is the
same as that shown in Fig. 4, excepting that a root
file management table T70 is added. This table T70
stores the file name of a root page of the home page
15 for each user identifier.

       The procedure of the control program P20 to
be executed when the load increases is illustrated in
Fig. 19. This procedure is the same as that shown in
Fig. 8, excepting that Step 1310 shown in Fig. 8 is
20 replaced by Step 1800. Only Step 1800 different from
that shown in Fig. 8 will be described. After a server
is selected at Step 1309, the root file management
table T70 is referred to at Step 1800 to instruct the
selected server to register the root file name
25 corresponding to the user identifier. Thereafter,
similar to Step 1310 shown in Fig. 8, the load
allocating apparatus d100 is instructed to change the
server address correspondence table T30. After the

completion of this change, the charge information is
changed. A newly selected server has initially a
standard root file name and changes (registers) the
root file name to thereby enable to access the correct
5 home page.